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DEVICE FOR DETERMINING THE CHARACTERISTICS OF A RUNNING MATERIAL WEB

The invention relates to an apparatus for the determination of characteristics of a running material web and/or of a machine for its manufacture and/or refinement, in particular for use in paper making machines, preferably in the dryer sections of paper making machines, with at least one measuring device.

For the optimisation of the manufacturing process of material webs, in particular of paper webs, it is desirable to know the operating state, for example of a paper making machine, and also its behaviour on changes of the machine settings as well as possible. For this purpose mathematical models are also used which describe the entire paper making machine or individual sections of the paper manufacture. For the optimisation of such models and also for the control or regulation of the individual devices used in the manufacturing process, for example in a dryer section of a paper making machine, measuring devices are used in order to collect data which relate to different measured parameters, for example the moisture content of a paper web or the surface temperature of dryer cylinders. These data can serve as a basis for the models which describe the manufacturing and/or refinement process and be made available to control or regulating units by which the conditions at individual machine sections can be changed, for example by controlling corresponding setting members.

Stationary measuring devices are known, with which spatially fixed measurements can be carried out with respect to one measured parameter at one measurement location, as well as scanners which include a sensor movable transverse to the web running direction.

Sub B2 It is the problem (object) underlying the present invention to provide an apparatus of the initially named kind which can be used as universally and variably as possible and which can also be used at paper making machines.

The solution to this problem takes place through the features of claim 1 and in particular in that the measuring device has at least two degrees of freedom of movement respectively corresponding to a rotary movement or a linear movement for the detection of data relating to at least one measured parameter at a plurality of measurement locations.

Degrees of freedom of movement or degrees of freedom are used here to describe movements of the measuring device which can each not be produced by combinations of other movements respectively corresponding to one degree of freedom. Through the invention an apparatus is provided with a measuring device which can be moved in diverse manner and which can be ideally aligned as a result of its mobility with the individual measurement locations, and in particular can be used in regions of the paper making machine to which access is difficult, for example between the dryer cylinders of a dryer section of the paper making machine. The provision of a plurality of degrees of freedom makes it possible to intentionally so align the measuring device or a sensor of the measuring

device that different measurement locations can be targeted one after the other which can, for example, not be reached with a scanner which is only movable along a straight line. The material web or machine to be investigated can be scanned with the measuring device of the invention also following any desired irregular pattern by investigating measurement locations distributed irregularly over the material web, the machine and/or the environment of the material web or machine one after the other. The investigation of the environment relates in this respect for example to the detection of data concerning a measured parameter which relates to a characteristic value of the air, for example its temperature or moisture, or of an air flow, for example its direction or speed, in the region of the material web or of the machine. The provision in accordance with the invention of a plurality of degrees of freedom also makes it possible to position the measuring device in two steps by it first being moved, for example by a linear movement, into the vicinity of the respective measurement location and by it being orientated, subsequent to this coarse adjustment, as part of a fine adjustment, for example, by a rotary movement such that the respective measurement location is precisely targeted. Each measurement location can thus be moved to quickly and nevertheless with a high precision, and in particular in a reproducible manner, by an appropriate design of the drive of the measuring device.

In accordance with a preferred embodiment of the invention, the measuring device is movable during the measurement and in particular without interruption of the data detection.

In this way, profiles of the respective measured parameter having any shape can be recorded at the material web or at the machine, and indeed in particular also transverse profiles and profiles in the longitudinal direction of the material web or in the direction of the machine or the process.

In accordance with a further preferred embodiment of the invention, the measuring device is simultaneously able to carry out a plurality of movements each corresponding to one degree of freedom.

The versatility of the measuring device of the invention is further increased in this manner. The measuring device can also already be pre-set within the framework of a coarse adjustment during the moving towards each measurement location to be investigated such that the subsequent fine adjustment only requires very little time.

In accordance with a further preferred embodiment of the invention, the measuring device is movable along three longitudinal axes preferably extending perpendicular to one another.

In this way, each point of a Cartesian coordinate system can be moved to with the measuring device, with the measuring device, in a particularly preferred variant, being movable in the longitudinal direction of the material web, perpendicular to the direction of movement of the web and in a vertical direction.

In a further preferred variant, the measuring device can additionally be rotatable about three axes which preferably extend perpendicular to one another, with the rotational axes being able to coincide with the three longitudinal axes which extend pair-wise perpendicular to one another. In this way, a measuring device having six degrees of freedom is provided which is characterised by a particularly high movement ability and thus versatility.

The measuring device can also have degrees of freedom corresponding exclusively to each rotary movement, also without the possibility of linear movements, and be rotatably mounted, for example, about two or three rotational axes which each stand pair-wise perpendicular on one another.

In accordance with a further preferred embodiment of the invention, the orientation of at least one longitudinal axis and/or rotational axis of the measuring device can be changed in space. This can be realised, for example, in that the measuring device is attached to a beam or frame which is movable relative to the material web or the machine in order to change in this way the location of a track or of a joint for the measuring device and thus the respective longitudinal or rotational axis in space.

It is also possible to movably attach the measuring device directly to the machine without such beams or frames.

Furthermore, the measuring device can be provided in the form of a mobile unit which can be used at different positions of a machine. Such a

measuring device can in particular be used for corrective measurements, for example for defect or error location.

In accordance with a further preferred embodiment of the invention, the measuring device is movable via a joint, in particular via a ball joint, which enables a pivotal movement in at least one plane.

A particularly good movability of the measuring device results in this way. A ball joint allows the carrying out of pivotal or rotational movements about a plurality of axes in simple manner. A measuring device which can be used in particularly versatile manner can be provided simply by a combination of the pivotal or rotational movements enabled by means of the joint with a single linear movement.

In accordance with a further preferred embodiment of the invention, a plurality of measuring devices, in particular provided in the form of interchangeable measuring heads, can be combined into one unit.

The measuring devices can, for example, be attached to a common frame or beam via which the individual measuring devices can be connected to a common control unit, drive unit, supply unit, data detection unit and/or evaluation unit. A particularly efficient utilisation of the individual components results in this manner. The investigation of the material web or of the machine with respect to different measured parameters can take place by the simultaneous use of measuring devices of different design or by the use of interchangeable measuring devices or measuring heads. For this purpose, the frame or the beam, to which the interchangeable

measuring devices or measuring heads can be attached, is preferably provided with at least one measuring location compatible with the individual measuring devices.

In accordance with a further preferred embodiment of the invention, the measuring device is attached to a frame which preferably extends transverse to the web running direction beneath the machine or over the machine and which is preferably supported on both sides of the machine.

In this manner, the measuring device can be moved, for example in the manner of a hangar crane, beneath or above the dryer section of a paper making machine in order, for example, to scan a dryer cylinder of the dryer section, with the measuring device being used as a service device for fast and simple diagnostic measurements in particular at new machines.

If, in accordance with a preferred variant, the frame is movable in the running direction of the material web or in the direction of the machine or the process, data can be collected about a plurality of dryer cylinders arranged in series. The measuring device can additionally be movable in the vertical direction and, for this purpose, be arranged for example at the free end of a beam extending in the vertical direction. The measuring device can in this way, for example, be raised or lowered into intermediate spaces between dryer cylinders spaced in the machine direction.

The solution of the problem underlying the invention also takes place by the features of the independent claim 29 and in particular in that the measuring device is rotatable about an axis at a plurality of measurement

locations for the detection of data relating to at least one measured parameter.

Such a measuring device can, for example, be attached to a beam projecting in the vertical direction or transversely to the web running direction into a machine, for example into intermediate spaces between suction rolls or dryer cylinders. In this manner, a plurality of measurement locations at the material web or at the machine can be investigated without having to move the beam relative to the machine or to linearly move the measuring device relative to the beam.

Generally any kind of measuring apparatus can be used as the measuring device with which the material web, the machine or the environment can be investigated with respect to at least one parameter relevant to the manufacturing or refining process. Possibilities include, for example, sensors working with visible, for example, polarised, light, sensors generally designed for the emission and for the reception of electro-magnetic radiation, for example IR sensors, sensors working with electrically charged particles, measuring devices equipped with temperature sensors, moisture sensors or devices for the investigation of air flows. The measured parameters with respect to which, for example, a paper web, the dryer cylinders and/or dryer sieves can be investigated in dryer sections of paper making machines are, for example, the thickness, the temperature or the moisture content of the material web or the paper web, the temperature and/or the dew point of the dry air used to dry the material web, the temperature prevailing at or in the region of the surface of the dryer cylinders of a paper making machine, the permeability at

dryer sieves, the speed of air flows present in particular at the surface of dryer sieves or the humidity at the individual machine components or at certain locations of the material web.

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Further preferred embodiments of the invention are set forth in the dependent claims, in the description and in the drawing.

The invention is described in the following by way of example with reference to the drawing. There are shown:

Figs. 1 and 2 perspective schematic illustrations in each case of a measuring apparatus in accordance with an embodiment of the invention having a plurality of degrees of freedom;

Fig. 3 a schematic side view of a measuring apparatus in accordance with a further embodiment of the invention used at dryer cylinders of a drying section in a paper making machine;

Fig. 4 a schematic view in the machine direction of a measuring apparatus in accordance with a further embodiment of the invention used at a dryer cylinder;

Fig. 5 a schematic side view of a measuring apparatus in accordance with a further embodiment of the invention

used in a dryer section of a paper making machine and protected by a protective device.

In Fig. 1, a measuring device 10 of an apparatus of the invention which is attached to a frame 12 shown schematically in Fig. 1 is indicated by a parallelepiped. The frame 12 includes a cross member 18 serving as a beam which extends over a paper making machine (not shown) and is supported at the base at both sides of the machine via support elements 20.

The measuring device 10 is attached to the free end of a vertically extending beam 19 which is coupled to the cross member 18.

The cross member 18 is movable relative to the support elements 20 in the running direction of the material web or in the direction x of the machine or process. It is also possible to provide support elements 20 movable in the x direction to which the cross member 18 is fixedly connected. The vertical beam 19 is in turn movable relative to the cross member 18 in a transverse direction y extending perpendicular to the machine direction x. The vertical beam 19 is also movable in the direction of its longitudinal extent relative to the cross member 18. so that the measuring device 10 can in this way be moved in the vertical direction z. It is also possible to provide a vertical beam 19 rigidly connected to the cross member 18 and a measuring device 10 movable relative thereto and thus in the z direction.

The arrangement explained above enables the measuring device to be moved to and fro in directions x, y, z extending in each case pair-wise

perpendicular to one another and thus to be positioned at any location in space.

Furthermore, the measuring device 10 is attached to the beam 19 via a joint 14, for example a ball joint, and rotatable about three rotational axes x', y'. z' each extending pair-wise perpendicular to one another, and indeed each in both directions and about at least almost 360°, as indicated by arrows α, β, γ in Fig. 1. In the embodiment shown, a rotational axis z' coincides with the vertical direction z defined by the vertical beam 19, whereas the two other rotational axes x', y' are each offset parallel to the corresponding longitudinal directions x, y.

The rotation of the measuring device 10 about the vertical axis y' or y can take place by the rotational mounting of the measuring device 10 at the vertical beam 19 or by rotation of the vertical beam 19 about its own longitudinal axis.

The measuring device 10 of Fig. 1 has six degrees of freedom with the three linear movements and the three rotational movements and can thus be moved to any point in space, on the one hand, and oriented anywhere in space at this point, on the other hand.

Fig. 2 shows a measuring device 10 which likewise has six degrees of movement freedom and which is movable along longitudinal axes x, y z oriented in accordance with Fig. 1 and each extending pair-wise perpendicular to one another. In contrast to the embodiment of Fig. 1, the measuring device 10 is attached to the free end of a beam or boom 22

extending in the transverse direction y via a joint 14, for example a ball joint, such that the measuring device 10 can be rotated about rotational axes x', y', z' likewise oriented in accordance with Fig. 1 and each extending pair-wise perpendicular to one another. In this embodiment, the rotational axis y' coincides with the longitudinal axis y of the boom 22 extending transversely to the web running direction or the direction x of the machine or process.

The boom 22 is coupled to a vertical beam 24 and is movable in the direction of its longitudinal extent y relative to the beam 24. It is also possible to provide a rigid connection between the boom 22 and the vertical beam 24 and to provide the measuring device 10 movably along the boom 22.

The lower end of the vertical beam 24 is connected to a support element 26 extending in the machine direction x. The movability of the measuring device 10 in the x direction can be realised by moving the support element 26 in the x direction or by moving the vertical beam 24 along the support element 26.

With the embodiment of Fig. 2, a crane-like frame 12 is provided whose free end, which bears the measuring device 10, can be moved to any point in space to which the measuring device 10 can be oriented anywhere in space by turning about the axes x', y', z' in each case by at least almost 360°.

Fig. 3 shows the use of an apparatus of the invention which has a measuring device 10, which is attached to a frame 12 and likewise has six degrees of freedom, in a dryer section of a paper making machine, with the measuring device 10 being located beneath a row of dryer cylinders 16 which are arranged in offset manner and around which a paper web 11 to be dried is guided.

The measuring device 10 is attached to a joint 14, formed for example as a ball joint, which allows a rotation or pivoting of the measuring device 10 about rotational axes which can generally be oriented anywhere in space.

The joint 14 is connected to a cross member 28 serving as a beam which extends in the transverse direction y perpendicular to the direction x of the machine or process and is movable relative to the measuring device 10 attached to the joint 14. The cross member 28 in this manner forms a traversing track for the measuring device 10.

The cross member 28 is attached to a vertical beam 30 which extends in the vertical direction z and is movable in the vertical direction z in order to provide a vertical movement of the measuring device 10 in this manner.

The vertical beam 30 is movable along a support element 32 which extends in the machine direction x and which thus represents a track carrier enabling movements of the measuring device 10 in the machine direction x. The measuring device 10 can in this way be moved to and fro between the dryer cylinders 16 spaced in the machine direction x, as is

indicated by the arrangement illustrated only in outline in the right hand part of Fig. 3.

It can be seen from Fig. 3 that, for example, by a simultaneous movement of the measuring device 10 in the machine direction x and in the vertical direction z and by a rotation of the measuring device 10 about a rotational axis extending in the transverse direction y, a dryer cylinder 16 can be scanned such that a constant spacing is observed between the cylinder surface and the side of the measuring device 10 confronting the dryer cylinder 16.

Fig. 4 shows a measuring device 10 which is attached to a frame 12 formed in accordance with Fig. 2 and which likewise has six degrees of freedom for the carrying out of measurements at a dryer cylinder 16. The frame 12 can be installed at the operator side or the drive side of the paper making machine. The measuring device 10 is attached to a joint 14, provided for example in the form of a ball joint, and is arranged suspended from a beam or boom 36 such that the free end of the measuring device 10 is located in the vicinity of the cylinder surface.

In accordance with the embodiment of Fig. 2, the boom 36 is movable relative to a vertical beam 38 which is in turn movable relative to a support element 40 fixedly connected to the base 34 also serving for the support of the dryer cylinder 16.

In accordance with the invention, the measuring device 10 can also be attached directly to the respective machine without a frame 12, as is

illustrated for example in the embodiments of Figs. 1 to 4, and be movably mounted in the manner of the invention.

In Fig. 5, the measuring device 10, which corresponds for example with respect to its travel and movement capability to a measuring device described above in connection with Figs. 1 to 4 and which is movably attached to a cross member 28, serves for the investigation of the relationships at a suction roll 42 of a dryer section of a paper making machine.

The measuring device 10 is located beneath a dryer cylinder 16 at which a scraper 44 is arranged. A protective device formed by a sheet metal shield 46 is provided for the protection of the measuring devices 10 against paper or paper residues detached from the dryer cylinder 16 by means of the scraper 44. The measuring device 10 is protected from above by the sheet metal shield 46 without impairing the measurements carried out by means of a measuring region 10a confronting the suction roll 42. The sheet metal shield 46 can be fixedly attached to the machine and extend along the whole movement region of the measuring device 10. It is also possible to mount the sheet metal shield 46 or another protective device to the movable measuring device 10.

Furthermore, a correspondingly designed scraper 44 can alternatively or additionally serve as a protective device for the measuring device 10 and, for example, be provided with a downwardly extending metal sheet which shields the measuring device 10 from downwardly falling articles.

The measuring device 10 is also protected in the case of a web tear by a protective device of the kind described above.

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